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(Plate xxxvii.)

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Both *Bovista* and *Bovistella* are included in the family Lycoperdaceae. Although species of each genus are not numerous, they are fairly widely distributed, save the Australasian species which, with one exception, are limited to this biologic region.

The name *Bovista* was first used by Dillenius (1719) and later in a generic sense by Persoon (1801); but it was not until the appearance of Morgan's paper (1892) that members of the genus came to be recognized in their present sense. Prior to this the name appears to have been loosely applied to any lycoperdaceous plant without a sterile base, as reference to the Gasteromycetes in Saccardo's *Sylloge Fungorum* (1888) will show, for herein are included under *Bovista* members of the genera *Lycoperdon*, *Bovista*, *Bovistella*, *Catastoma* and *Calvatia*. Cooke (1892) likewise appears to have had but a vague idea as to what should be included in *Bovista* for, according to Lloyd (1905), of the seven Bovistas included in this work, five are Catastomas and one is a *Calvatia*. On account of the habit of members of the genus, Lloyd (1902, *a*) places it in the tribe Bovisteae, or "tumblers."

Bovistella was erected by Morgan (1892) as a monotypic genus. His conception of the genus was one possessing the capillitium of *Bovista* with, in addition, a sterile base. In his earlier papers Lloyd (1902, *a*, *b*) claimed that the presence of a sterile base was not a good character on which to separate these two genera (basing his argument on the fact that it has not been considered of sufficient moment to separate *Globaria* from *Lycoperdon*) and proposed to separate the two upon habit, *Bovista* being a genus in which plants break away at maturity from the point of attachment, *Bovistella* persisting as does *Lycoperdon*. The writer would follow Lloyd's emendation in so far as the habit is concerned, for it is the only character upon which separation is possible.

In a later paper Lloyd (1905) further emends *Bovistella* to include all plants possessing a rooting base together with either pedicellate spores or capillitium of the *Bovista* type or both. Thus many species included in *Lycoperdon* (possessing the capillitium of *Lycoperdon*) are by Lloyd placed in *Bovistella*. He claims (1906, *a*) it would simplify matters to take from the genus *Lycoperdon* (which is a large and unwieldy genus) a natural section and place it in another genus with which the section agrees in a prominent character and in which it differs from the remainder of the genus *Lycoperdon*. The writer cannot agree with Lloyd in this grouping, for capillitium characters are of greater importance than spore characters, especially when they are so well defined as in the different genera of

the Lycoperdaceae. It would simplify matters to erect a section under *Lycoperdon* for those species possessing pedicellate spores, and thus save the confusion that would otherwise be caused.

Structure of the Mature Plant.

A mature plant consists of two groups of tissues, (*a*) peridium, (*b*) gleba.

(*a*) *Peridium.*—This is invariably globose, elliptical or depressed-globose and consists of two distinct tissues, (1) the exoperidium, (2) the endoperidium. The exoperidium in the mature plant usually falls away, leaving the endoperidium exposed, or may be partially persistent as in *Bovista purpurea*, here appearing in the nature of a much broken, thin and fragile outer covering (Plate xxxvii, fig. 2). It consists either of loosely interwoven non-gelatinized hyphae, or else pseudo-parenchymatous tissue. Frequently it persists on the endoperidium as minute scales or blunt points, giving to this structure a roughened appearance.

The endoperidium is in the nature of a very thin, papyraceous membrane enclosing the gleba and perforated by a single apical orifice; it varies in colour from bay-brown to purple, the colour being fairly constant with the species. Microscopic examination shows the endoperidium to consist of intricately interwoven, gelatinized hyphae and in addition (in *Bovista brunnea*) are present numerous ramifying hyphae, several times the diameter of the normal hyphae, thick-walled and filled with coarse granular matter. The apical orifice (mouth) through which the spores escape at maturity is usually circular or elliptical in outline and may be plane or surrounded by a slightly elevated, toothed margin.

(*b*) *Gleba.*—The whole of the tissue enclosed within the endoperidium is termed the gleba. At maturity it consists of a mass of short branched capillitium threads immixed with very numerous spores. Each thread is of a peculiar structure, consisting of a thick stout stem from which arise numerous dichotomously branched acuminate lateral branches (Plate xxxvii, fig. 1). These structures are characteristic of the genera *Bovista* and *Bovistella*. The wall of the thread varies in thickness and colour and is usually perforated with numerous pits or depressions, which penetrate to the lumen. Their function is unknown. The threads vary according to the species in the degree of branching, thickness of the wall of the main stem, length of the branches and presence or absence of pits. In all the species examined no septa are present. In the mature plant these threads appear aggregated into small balls, giving to the ripe gleba a granular appearance.

The spores are obovate or globose, thick-walled, 5-6μ in diameter, and possess either a rough or a smooth epispore. All are some shade of brown. To each is attached the sterigma (absent in *Bovistella pusilla*) an appendage which is hyaline, varies in length from 10 to 25μ, and is usually acuminate.

Dehiscence of the spores is effected through the mouth, but the exact manner of emergence is unknown. The capillitium threads are slightly hygroscopic and possibly owing to this and to the expansion and contraction of the endoperidium brought about by changes in atmospheric humidity or temperature, spores are forced through the opening and dispersed by the wind. In *Bovista* plants break away at maturity from the point of attachment and are rolled over the ground by the wind, often for considerable distances. Doubtless numerous spores are forced out through repeated blows upon the endoperidium during the rotation of the plants when being carried along in this manner. As *Bovistella* remains attached to the substratum at maturity, this probable method of spore discharge

cannot occur. The development of one of the species of the genus *Bovista* is being published elsewhere.

Artificial Key to the Genera.

Plants breaking away from the point of attachment at maturity ..... *Bovista*
Plants remaining attached to place of origin, not breaking away at maturity ..... *Bovistella*

BOVISTA Dillenius *ex* Persoon.
Syn. Meth. Fung., 1801, p. 136.

Plants breaking away from the point of attachment at maturity.

Peridium globose, subglobose or shortly pyriform; consisting of an outer, usually fugacious exoperidium, and a membraneous, tough, firm endoperidium, which dehisces by an apical, definite or indefinite mouth.

Gleba without a sterile base; capillitium of free threads, each consisting of a thick stem and dichotomous, tapering, acuminate branches.

Spores coloured, continuous, rough or smooth, globose, obovate or elliptical, pedicellate or apedicellate; basidia tetrasporous.

Habitat.—Solitary on the ground.

Distribution.—Europe; North and South America; Australia; New Zealand.

Two species only are known in Australia and/or New Zealand, both being confined to this biologic area.

1. BOVISTA BRUNNEA Berkeley.
Flora N.Z., vol. 2, 1855, p. 119.

Peridium depressed-globose, up to 2.5 cm. diam., with a minute rooting base which usually falls away at maturity; exoperidium white, evanescent; endoperidium chestnut-brown or pallid umber-brown, firm, smooth, shining. Mouth up to 2 mm. diam., irregularly circular or indefinite and irregularly torn, slightly erumpent, toothed or entire, frequently almost plane.

Gleba pallid ferruginous-brown; capillitium of the usual type but more scantily branched, walls thin and pitted. Spores globose or obovate, 4-6μ, pedicel tinted or hyaline, acuminate, 10-13μ long; epispore pallid-ferruginous, closely and finely verruculose, 1.5μ thick.

Habitat.—Solitary on the ground.

Distribution.—Australia; New Zealand: Shore of Lake Te Anau, Otago, Jan., 1920 (E. H. Atkinson), Methven, Canterbury, Feb., 1925, Immature (J. C. Neill).

This species is characterized by the firm, dark-brown, smooth and shining endoperidium, stout, sparingly branched, thin-walled capillitium, and pallid, distinctly verruculose spores.

Two collections from Lake Te Anau were forwarded to Lloyd for determination (Nos. 73, 572). He determined one as *Bovista brunnea*, the other as *Bovistella bovistoides*. The writer has since ascertained that both collections consisted of these two species.

Lloyd (1906, *b*) believes this species to be an old weathered form of *Bovista tomentosa* Vitt., for he finds, in certain Australian collections, the immature specimens possess a finely spinous exoperidium. As there is no indication in Vittadini's work that he described immature plants, the writer fails to see where the connection between the two lies, for this reasoning may equally well be applied to *Bovistella bovistoides*, as the immature plants of this species also possess a finely tomentose exoperidium.

The type was collected by Colenso on the banks of the Manawatu River, Wellington, N.Z., and is now preserved in the Kew Herbarium. The writer has seen no specimens of this species from Australia.

2. Bovista purpurea Lloyd.

Mycological Notes, 1923, p. 1201, Figs. 1, 2, 5, 9.

Peridium globose or depressed-globose, up to 2.5 cm. diam., with a small pulvinate rooting base; exoperidium thin, dingy-white or brown, evanescent, falling away in irregular flakes or scales, but partly persisting towards base; endoperidium usually lead-coloured, often purplish, smooth, firm, shining, dehiscing by an apical, irregularly torn, circular or elliptical mouth, which is erumpent, irregularly toothed and up to 5 mm. diam.

Gleba purple-brown; capillitium of the usual type, but stout, freely branched and not pitted. Spores obovate or globose, 5-6μ diam., pedicels hyaline, acuminate, up to 12μ long; epispore chestnut-brown, verruculose, 1μ thick.

Habitat.—Solitary on the ground.

Distribution.—New Zealand: Mapua, Nelson, May, 1922 (G.H.C.; Type coll., Lloyd No. 700), Ashburton, Canterbury, Jan., 1925 (J. C. Neill), Blenheim, Marlborough, May, 1925 (J. C. Neill).

This species is characterized by the dark colour, flaking endoperidium, distinctly verruculose spores and stout, strongly branched, non-pitted capillitium.

Excluded Species.

Of the seven species recorded in Cooke's Handbook (1892) one, *B. brunnea*, is valid; *B. Muelleri*, *B. hyalothrix*, *B. hypogea*, *B. anomala* and *B. cervina* should be placed in *Catastoma*, and *B. olivacea* in *Calvatia*.

Bovistella Morgan.

Journ. Cincinnati Soc. Nat. Hist., vol. 14, 1892, p. 145.

Plants remaining attached to place of origin, not breaking away at maturity; with a well developed rooting base.

Peridium globose or pyriform, of two layers; an external, thin, usually fugacious exoperidium, and an inner thin, flaccid, membraneous endoperidium which dehisces by an apical definite or indefinite mouth.

Gleba with or without a well defined sterile base; capillitium of free threads, each consisting of a thick stem and dichotomous, tapering, acuminate branches. Spores coloured, continuous, rough or smooth, globose, obovate or elliptical, pedicellate or apedicellate.

Habitat.—Solitary on the ground.

Distribution.—Europe; North America; India; Australia; New Zealand.

Artificial Key to Species.

Spores pedicellate—	
Peridium pallid-tan, finely tomentose	1. *B. verrucosa.*
Peridium dark brown, areolate	2. *B. bovistoides.*
Spores apedicellate	3. *B. pusilla.*

1. Bovistella verrucosa, n. sp. Plate xxxvii, figs. 3, 7.

Peridium globose or shortly pyriform, up to 15 mm. diam.; with a strong, well-marked rooting base; exoperidium in the nature of a very delicate layer, soon more or less completely flaking away; endoperidium dingy-white or pallid-tan, minutely and delicately tomentose, appearing almost smooth, very thin and fragile, flaccid, opening by an apical, irregular, indefinite plane mouth.

Gleba bay-brown, sterile base absent; capillitium threads of the usual type, pitted. Spores globose, 4-6μ, pedicels hyaline, acuminate, up to 12μ long; epispore tinted, finely and closely verrucose, 1.5μ thick.

Habitat.—Solitary on the ground.

Distribution.—South Australia: Monarto South, Sept., 1922, J. B. Cleland. Type, in Herb. Cleland.

The small size, pallid colour and tomentose nature of the endoperidium and rough pallid spores characterize this species.

2. Bovistella bovistoides (Cooke and Massee) Lloyd. Plate xxxvii, figs. 4, 6, 8.

Myc. Notes, 1906, p. 247.—*Mycenastrum bovistoides* Cke. et Mass., *Grev.*, vol. 16, 1888, p. 26.—*Scleroderma bovistoides* (Cke. et Mass.) De Toni, in Sacc. *Syll. Fung.*, vol. 7, 1888, p. 489.

Peridium globose, depressed-globose or shortly pyriform, up to 2 cm. diam., with a strong rooting base which frequently attains a length of 1.5 cm.; exoperidium thin, white, persisting as small areolate areas over the upper part of the endoperidium, but scanty or absent from lower, frequently falling away completely when the endoperidium appears marked with lines arranged in an areolate manner; endoperidium flaccid, dull bay- or chestnut-brown, darker basally; mouth apical, usually elliptical, frequently indefinite, slightly erumpent and toothed, sometimes almost plane.

Gleba olivaceous, becoming umber, sterile base absent; capillitium of the usual type, threads much branched, thick-walled, pitted, dark chestnut. Spores globose, seldom obovate, 4-6μ diam., pedicels tinted, attenuate, up to 15μ long; epispore chestnut-brown, minutely and delicately verruculose, almost smooth, 1μ thick.

Habitat.—Solitary on the ground.

Distribution.—India; Australia; New Zealand. South Australia: Flinders Range, near Pt. Augusta, Aug., 1922 (J.B.C.), Mr. Zeitz coll. (Herb. Clel.); New South Wales: Wagga, July, 1914 (J.B.C.); New Zealand: Banks's Peninsula, Dunedin, Otago, July, 1922 (Miss H. K. Dalrymple), Tapanui, Otago, March, 1922 (G.H.C.).

Different collections of this species vary in the size and extent of the areolate markings. As it is impossible from the material at hand to separate any one collection from another, it is thought advisable to keep all together. The colour of the peridium varies much according to the age of the plant, so that it cannot be used as a specific character.

The rooting base separates this from *Bovista brunnea*, which otherwise it resembles closely. As this structure may frequently be absent from old weathered specimens, and as the areolate markings also disappear, it is extremely difficult to place old specimens of either species. The spore markings and capillitium in such cases serve as the only characters by which separation can be made, for the spores of *Bovista brunnea* are more coarsely verruculose than those of *Bovistella bovistoides*, and the capillitium is more scantily branched, more pallid in colour and the walls are thinner.

The collection made at Tapanui is so well marked, and has such a small rooting base that the writer was at first inclined to separate it and place it under the genus *Bovista*, but critical examination of the capillitium and spores shows it to be but a strongly marked form of *Bovistella bovistoides* with a weak development of the rooting base.

The species is characterized by the areolate markings and dark colour of the endoperidium, chestnut, verruculose spores and stout, strongly branched, thick-walled, pitted capillitium.

3. Bovistella pusilla Lloyd.
Mycological Notes, 1910, p. 457.

"Plant globose, 1-1.5 cm. diam.; cortex smooth, peridium thin, flaccid, sterile base none; gleba dark brown; capillitium deeply coloured, with numerous tapering branches. Spores compressed-globose or slightly ovoid, 4 × 4μ; deeply coloured, smooth, with short but distinct apiculus.

Brisbane, E. Jarvis".

The writer has not seen specimens. The description given is that of the original. The species is characterized by the apedicellate spores.

Excluded Species.

(*a*) *Bovistella aspera* (Lev.) Lloyd, *Lyc. Aus.*, 1905, p. 28 = *Lycoperdon asperum* (Lev.) De Toni, in Sacc. *Syll. Fung.*, vol. 7, 1888, p. 119.

(*b*) *Bovistella australiana* Lloyd, *Lyc. Aus.*, 1905, p. 28.

(*c*) *Bovistella cuprica* Lloyd, *Letter No. 60*, 1915, p. 9. This the writer believes to be a *Lycoperdon*, but the description is so poor as to make the placing in any genus uncertain.

(*d*) *Bovistella glabrescens* (Berk.) Lloyd, *Lyc. Aus.* 1905, p. 28 = *Lycoperdon glabrescens* Berk., *Fl. Tas.*, vol. 2, 1860, p. 264.

(*e*) *Bovistella Gunnii* (Berk.) Lloyd, *Lyc. Aus.*, 1905, p. 29 = *Lycoperdon Gunnii* Berk., *Fl. Tas.*, vol. 2, 1860, p. 265.

(*f*) *Bovistella rosea* Lloyd, *Myc. Notes*, 1906, p. 248.

(*g*) *Bovistella nigrica* Lloyd, *Myc. Notes*, 1922, p. 1115.

All are excluded from *Bovistella* as they possess the typical *Lycoperdon* capillitium. They will be dealt with under the genus *Lycoperdon* in a subsequent paper.

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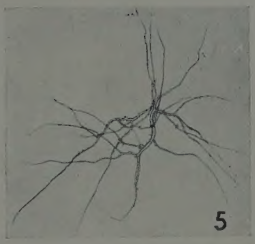
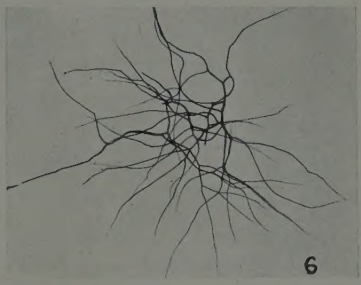
EXPLANATION OF PLATE XXXVII.

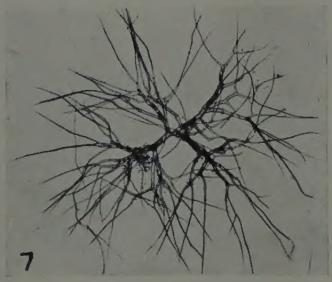
1. Capillitium of *Bovista purpurea* Lloyd. × 110. This shows the main stem and dichotomous, tapering branches.
2. *Bovista purpurea* Lloyd. × $\frac{2}{3}$. The specimen in the centre shows the partly adhering exoperidium.
3. *Bovistella verrucosa* G. H. Cunn. Natural size. Note the roughened surface of the endoperidium.

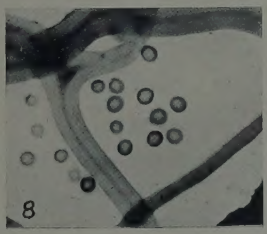
4. *Bovistella bovistoides* (Cke. et Mass.) Lloyd. $\frac{2}{3}$ × $\frac{2}{3}$. These specimens (from Tapanui) show unusual development of areolate markings.
5. Capillitium of *Bovista purpurea*. × 55.
6. Capillitium of *Bovistella bovistoides*. × 55.
7. Capillitium of *Bovistella verrucosa*. × 55. The opaque areas in the lumen are air bubbles.
8. Spores of *Bovistella bovistoides*. × 540. The hyaline pedicels are scarcely discernible. Note the thick-walled capillitium.
9. Spores of *Bovista purpurea*. × 540.

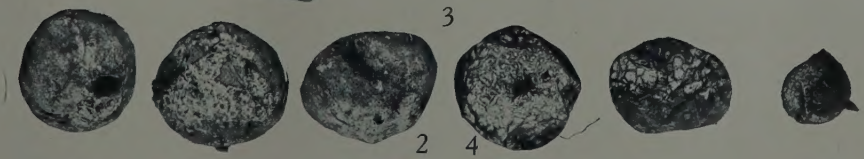
The photographs of the mature plants were taken by Mr. H. Drake, of this laboratory. The photomicrographs were taken by the writer, but the plates were developed and printed by Mr. Drake, to whom the writer's thanks are due.











Gasteromycetes of Australasia.

1, 2, 5, 9. *Bovista.* 3, 4, 6, 7, 8. *Bovistella.*